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ABSTRACT

In silent reading, short-memory tasks, such as semantic and syntactic processing, require a stage of phonetic encoding between visual representation and the actual extraction of meaning, and this encoding includes prosodic as well as segmental features. To test for this suprasegmental coding, an experiment was conducted in which subjects were given word lists to read silently. The last word in each list was to be read aloud. This word in each list was phonetically ambiguous, its syllabic stress dependent upon whether its syntactic function was that of a noun or a verb. The other words in the list carried stress identical to that of the "less-preferred" pronunciation of the ambiguous words, as determined unknowingly by the subjects beforehand. The less-preferred pronunciation was elicited in a majority of cases, indicating that there is a prosodic phonetic representation in short-term memory that is biasing pronunciation of the ambiguous word. It is hypothesized that cognitive parsing of written language parallels parsing in reception of spoken language, and that prosody is also used to mentally represent the phonetic structure of a sentence once it has been computed. Internal structural representations of reading, then, are based in an auditory rather than a visual medium. (PJM)

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PROSODIC ENCODING IN SILENT READING*

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In the lively debate concerning the issue of phonetic encoding in silent reading, results of experiments utilizing more naturalistic reading tasks (e.g. Kleiman, 1975) support the hypothesis that a stage of phonetic recoding mediates between the visual representation of writing and the eventual extraction of meaning. Experimental results cited as evidence for a direct visual encoding hypothesis involve unnatural reading situations (e.g. Kolers and Katzman, 1966) or lexical access rather than the larger task of reading running text (e.g. Meyer, Schvaneveldt and Ruddy, 1974; Meyer and Schvaneveldt, 1974). Whenever an experimental task requires the involvement of short-term memory, evidence is found that a phonetic representation is constructed (Conrad, 1972). When the task involves syntactic or semantic processing, as some of Kleiman's tasks do, a phonetic representation is also implicated. It is not surprising that the same result emerges in syntactic and semantic processing tasks as in short term memory tasks, since sentence parsing surely requires the utilization of short term memory.

Liberman (1970) and Mattingly (1972) suggest that our capacity for language is such that any kind of language processing requires phonetic encoding, although they have not elaborated on the exact character of the code. Conrad remarks that the "short term memory studies indicate so marked a preference for phonological coding in situations that make such coding penal, that they might almost be taken to support the view that speech coding is necessary in silent reading." (p. 211) Until now, reading studies have concentrated on demonstrating the presence of segmental features in the phonetic representation. If there is in fact a phonetic representation that readers are making use of, as there seems to be, it will presumably include other aspects of the phonetic code, including suprasegmental features. Thus we should be able to demonstrate the presence of prosody experimentally.

TESTING FOR THE PRESENCE OF PROSODY IN THE PHONETIC CODE

A familiar effect in psychological experiments is the response bias: Subjects "prefer" one response over others. Of course, this "preference" is not a conscious aesthetic decision. Rather, all other things being equal, subjects are more likely to respond one way than another, for a variety of reasons (familiarity, mental set), some of which we understand and some of which we do not. Psycholinguistic experimenters have exploited this effect, reasoning that if the subject could be manipulated to respond in a predictable way, then the property of the stimuli that was used to bias his response was psychologically salient (e.g. Mehler and Carey, 1967; Meyer and Schvaneveldt, 1971).

If prosody is present in silent reading, perhaps a response bias can be induced in subjects by presenting them written materials of a constant, unambiguous prosodic pattern, to be read silently. The presence of the bias, and therefore of prosody in the subjects' silent reading, can be established by its influence on the subsequent pronunciation of ambiguous material to be read

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aloud. The "preferred" prosody of the target material must be established beforehand to see if an obtained bias is, in fact, a result of the experimental condition, and care must be taken to assure that the priming stimuli bias the subjects' responses by virtue of their prosodic properties only, independently of any syntactic properties.

Since Kleiman has demonstrated that phonetic encoding does take place in the reading and comprehension of sentences, we might hope to obtain this phonetic bias effect for whole sentences under normal reading conditions. However, natural stimulus materials for such an experiment are extremely difficult to construct. It is more feasible to test for the presence of lexical stress contours, as in the experiment which I will describe. While it is true that this task does not require syntactic or semantic processing, as reading in a natural situation does, subjects are required to hold words in storage in the working memory for a decision, so the task is perhaps more like reading than other tasks which require only lexical access.

The crucial stimuli in the experiment were members of the class of bisyllabic words which are nouns or verbs depending on whether primary stress falls on the first or second syllable, respectively; for example: pervert, torment, transport. A member of this class was the final item in each of ten lists of bisyllabic words of different syntactic classes but similar primary stress placement. The baseline preference for the placement of primary stress was determined beforehand by having subjects read a long random list of arbitrary words in which they were embedded. The results of this pretest are given in Table 2, column A. In the experiment, the ambiguous word was preceded by eight bisyllabic words with a stress pattern like that of the less preferred pronunciation of the ambiguous word at the end. These lists were further embedded in a series of arbitrary lists, or "foils", of eight to eleven words. The lists were eight to eleven words long in order to place a heavy load on short term memory, based on Miller's (1956) estimates for the storage capacity of short term memory for unrelated items. The ratio of relevant lists to foils was one to eight to draw attention away from the special properties of the relevant lists, and there were ten relevant lists. (Relevant lists appear in Table 1.)

In order to direct attention away from the real purpose of the experiment, subjects were told that we were correlating reading rate with accuracy of recall. They were seated in front of a screen upon which appeared vertical lists of eight to eleven words. They were instructed to read each word on the list silently as fast as they could without missing any of the words, and to signal the experimenter that they were finished by pronouncing the last word on the list out loud. These responses were taped. The words on the screen disappeared and a single word appeared, to which subjects responded "yes" (it was on the list) or "no" (it was not on the list). This memory task was included in order to insure that subjects tried to store the lists for recall in short term memory. The experiment lasted approximately 15 minutes.

The results of the experiment are summarized in Table 2. Column A gives the percentage of times that the less preferred stress pattern for each ambiguous item was given in the pretest, and notes whether the less preferred reading was as a noun (that is, with initial syllable stress) or as a verb (with final syllable stress). Column B gives the percentage of trials in which this less preferred stress pattern* was elicited in the biasing condition. The number of subjects is given in parentheses in this column. Column C gives the percentage

* Note that the term "less preferred" is used for the stress pattern that was less preferred by the pretest subjects (even though, in the biasing condition, it was often the preferred pattern).

of trials in which the less preferred pattern was used by subjects who answered the memory question correctly for that test list. The number of subjects answering correctly is given in parentheses.

Comparison of Columns A and B indicates a significant effect of the biasing lists on the stress of the ambiguous test item. In a Wilcoxon one-tailed sign test, this difference was significant at the .05 level.

The biasing effect becomes even more apparent if we take into account the attentiveness of the subjects. Subjects' performance on the memory test can be taken as a measure of attention. Column C gives the results just for subjects who answered the memory question correctly; comparison of Columns A and C shows a significant difference at the .01 level.

A further indication that the biasing manipulation was successful is that 90% of the variation between subjects in the number of shifted responses can be accounted for by their performance on the memory test. This correlation is graphed in Figure 1. The graph shows a rather strong correlation, over a wide range of subject performance. If we look at both ends of this range, at the two least attentive and the two most attentive subjects, we find that where performance on the memory task was 69-70%, subjects gave the less preferred reading only 20% of the time, while the two subjects who got 88% of the memory questions correct gave the less preferred reading 60% of the time.

It should be noted that the response shift was not equal for all the items tested. While a large effect was achieved for the words digest, permit, project, conduct and pervert, other items (object, present, progress) exhibited little effect (or even a reverse effect). Incline is the clearest case: In no trial was it possible to get a subject in the test situation to pronounce incline as a noun, with first syllable stress. The averages given in column A are for preferred pronunciations across ten subjects. These figures indicate that one pronunciation is preferred over another by, say, eight people out of ten. What they do not indicate is how strong each individual's preference is. Though the former is much easier to measure, it provides only a very rough estimate of the latter -- which is, of course, what is really relevant to the biasing experiment. The failure of the experimental manipulation for incline may well be due to the fact that while approximately one person out of ten prefers it as a noun, most people may have it in their lexicons only as a verb. For these people, its stress pattern would be completely unshiftable however psychologically real stress patterns are in reading. This suggests that for this kind of experiment it would be quite proper, and indeed optimal, to select words whose baseline frequency is about equally balanced between noun and verb.

The results of this experiment agree with the finding of other investigators that visually presented words are mentally represented in phonetic form in short term memory. In this case a significant influence of stress pattern for silently read words was demonstrated. Clearly readers do recode phonetically. In terms of mental processing, this requires extra steps and probably extra time. If we assume that the processor does things as quickly and efficiently as possible, we must conclude either that reading would be impossible without phonetic mediation, or else that the phonetic code provides a valuable advantage. It is possible that the presence of prosody in the phonetic code can contribute to an explanation of such an advantage.

For example, readers already have a parsing mechanism for spoken language which presumably applies to a phonetic representation. If readers did not recode phonetically, then they would have to be processing a visual representation. And this would imply that they use different parsing techniques for reading. There is evidence that the phonetic code and the visual code are retained in working memory for different periods of time, and these differences

arguably would require entirely different parsing strategies. For example, the amount of lookahead required would in all probability be different; the resolution of temporary ambiguities (e.g. by a guessing strategy or a waiting strategy) might well also be different. The choice for the cognitive system can thus be seen as a choice between adapting the parsing device for speech so that it can handle visual representations, or adjusting the visual representation so that the device already available can deal with it. Notice that while there are no other visual stimuli in the environment that require anything like a linguistic analysis, we use phonetic representations in speaking and hearing all the time. If the reader can translate written stimuli into the phonetic code, he can make use of the parsing device that is already available.

Readers apparently choose the option of translating written material into a phonetic code. Furthermore, the results of this experiment indicate that the reader's phonetic code includes prosodic as well as segmental information. It is interesting to speculate, then, whether and how a prosodic representation could facilitate in processing written sentences. It is clear that the parser needs access to some kind of working memory for the temporary storage of the input. We know that structured material is retained much better than unstructured material, such as random lists of words. It is conceivable that prosody provides some structure in the working store for words that are received as simply an unstructured linear sequence. At the very least, we can imagine the parser using prosody to assist in remembering words while the syntactic analysis is being performed.

Some prosodic information -- contrastive stress, pauses, question intonation -- is represented by punctuation and other explicit symbols in the written text. Some is undoubtedly filled in as the syntactic properties of the text are discovered. This is not a problem specific to reading, since apparently the same situation exists in speech perception: Lieberman (1965) provides a striking demonstration that prosody is greatly underdetermined by the acoustic information in an utterance. Thus this advantage of a phonetic code is quite separate from its value as a source of structural information about a sentence in auditory perception. I am arguing that it is useful as a medium of representation in reading, even though here the prosodic properties of the sentence are contributed by the reader and carry no extra information.

An even stronger hypothesis (though one that it is not easy to test) is that we also use prosody to mentally represent the phrasal structure of a sentence once it has been computed. As linguists discussing language, we use visual-spatial representations of phrase structure; for example, we draw tree diagrams on the blackboard. But the internal structural representations used by hearers and readers during sentence processing may well be parasitic on an auditory rather than a visual medium. The details of this hypothesis remain to be explored. It is not hard, for example, to see how prosodic phenomena could be used in representing phrasal <u>groupings</u>, as suggested by Cooper, et al. (1978), but it is more difficult to imagine how they could be employed to capture phrasal <u>categories</u>. However, this may show only that more ingenuity is needed on our part, rather than that the general thesis is false.

* I am grateful to Janet Fodor and Ignatius Mattingly for their many helpful suggestions in the development of this study.

TABLE 1

perhaps	garish	apply	liquid	portray
suggest	wrestle	prefer	garish	receipt
immense	foreign	belief	artist	restore
humane	mercy	extreme	fellow	guitar
giraffe	manage	defend	often	reflect
deny	common	balloon	flatter	opaque
insane	fountain	because	vanish	polite
garage	orange	enough	yellow	indeed
object	pervert	present	digest	progress
mellow	garage	cupid	fasten	tumble
cancel	believe	snuggle	table	dinner
apple	intense	jealous	crazy	hollow
heavy	mirage	scissors	forage	glisten
justice	arrange	follow	angel	penny
simmer	obtuse	normal	silly	nasty
anxious	despite	porous	barren	subtle
purple	instead	maybe	eager	rotten
permit	subject	incline	project	conduct

TABLE 2

% less preferred stress

	A	B	C
ITEM	PRETEST (N=10)	BIAS CONDITION	BIAS CONDITION (MEMORY QUESTION CORRECT)
conduct	10% (initial)	72%(18)	82% (11)
object	20 (final)	17 (18)	13 (15)
pervert	40 (initial)	77 (18)	77 (18)
present	30 (final)	28 (18)	29 (14)
digest	20 (initial)	39 (18)	38 (16)
progress	40 (final)	33 (18)	29 (14)
permit	20 (initial)	33 (18)	46 (11)
subject	30 (final)	33 (18)	33 (18)
incline	10 (initial)	0 (17)	0 (17)
project	30 (initial)	53 (17)	56 (17)

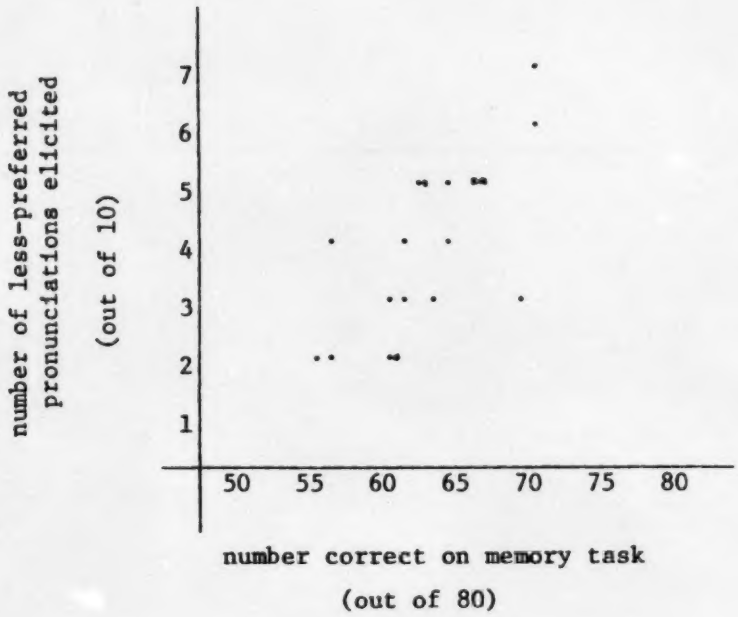
number of less-preferred pronunciations elicited
(out of 10)
7
6
5
4
3
2
1
50
55
60
65
70
75
80
number correct on memory task
(out of 80)

FIGURE 1

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